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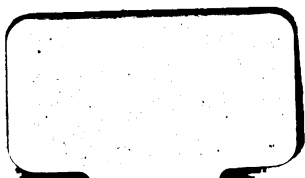
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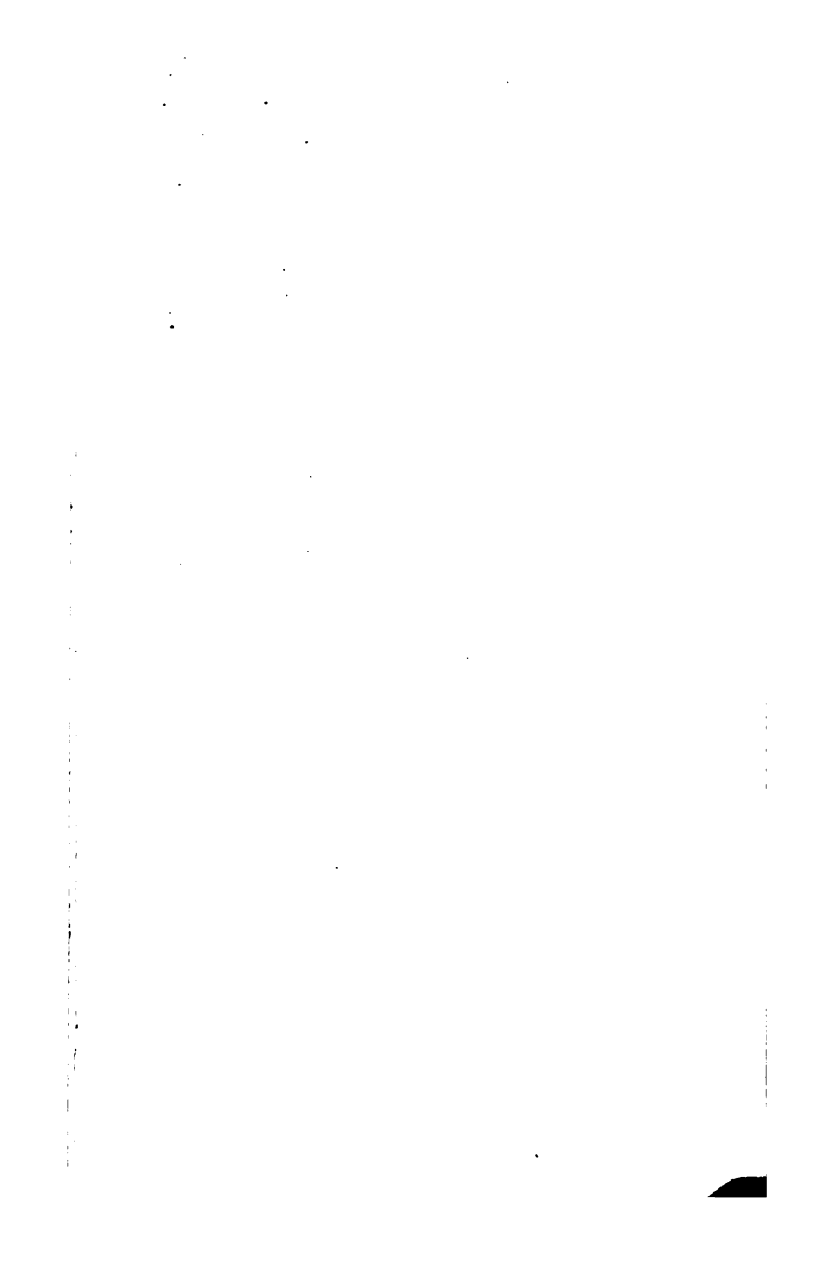
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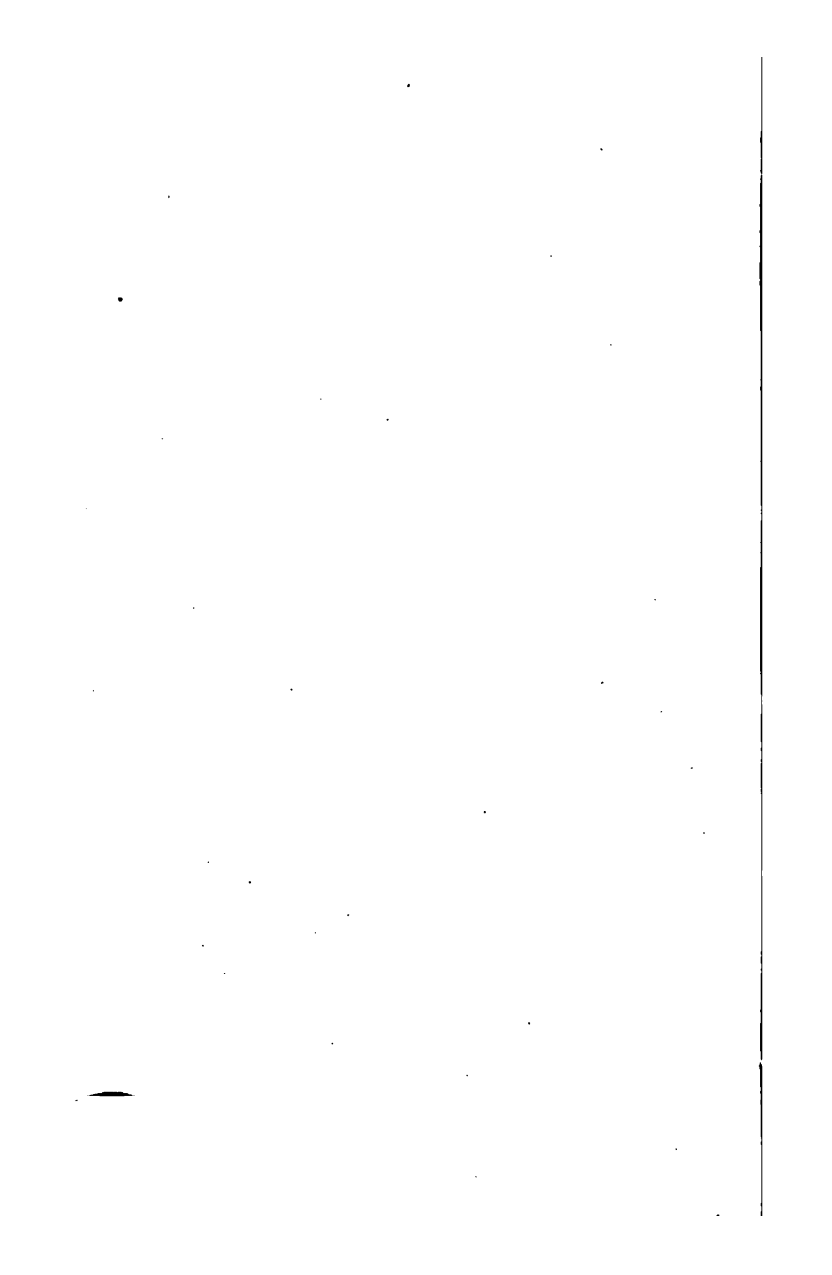


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GEOLOGICAL NOTES OF IRELAND.





GEOLOGICAL NOTES

OF

IRELAND.

BEING AN ACCOUNT OF THE FORMATION AND
LOCALITIES OF ITS MARBLES, STONE, &c.

As Useful for Constructive Works;

ALSO

COAL AND THE MINING DISTRICTS.

BY

WILLIAM HUGHES.

SECOND EDITION.

DUBLIN:

M^cGLASHAN & GILL, 50, UP. SACKVILLE-ST.

W. H. SMITH & SON.

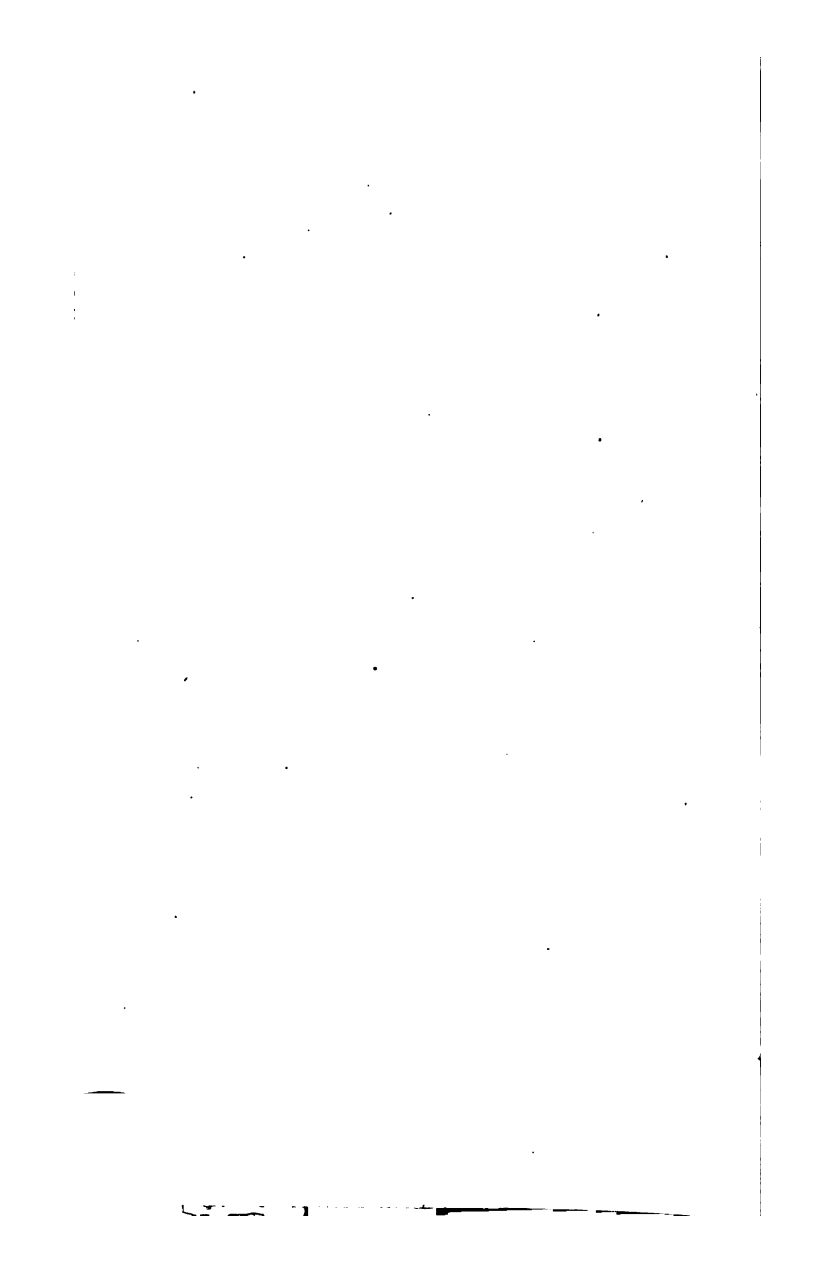
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TO
DR. THOMAS WILLIS, SEN.,
OF 18, BATHMINES-ROAD, DUBLIN,
WHO HAS SO OFTEN AIDED ME IN MANY
OF MY PREVIOUS HUMBLE LITERARY EFFORTS,
BOTH BY HIS ADVICE AND THE
PLACING OF HIS VALUABLE LIBRARY AT MY DISPOSAL,
SO FAR AS I MIGHT CONSULT ITS AUTHORITIES,
THIS SECOND EDITION OF
GEOLOGICAL NOTES OF IRELAND
RESPECTFULLY
is inscribed

THE AUTHOR.



INTRODUCTION.

THE study of Geology is, to many, perhaps the most pleasing and instructive of sciences. To the traveller and the tourist, who have made acquaintance with it in its most initiatory forms, it cannot fail to prove interesting, as recalling to mind at a single glance of the surrounding scenery through which business or pleasure may lead them, the geological formation of the country through which they pass. The serrated peak, the conical summit, the tabular, stair-like mountain, the precipitous cliff, the undulating

plain, all tell their own tale, leading the mind insensibly back to periods and ages of indefinite time, long and long before man existed upon this earth.

Ireland is peculiarly fortunate in this respect, as containing within it examples of almost every known formation ; and to this we are indebted for the varied scenic panorama which presents itself to the eye generally throughout the island. And, although in writing these pages it was more my intention to dedicate them to a particular profession, I am egotistical enough to imagine they may prove of some little interest to the general reader.

These chapters, originally written for the columns of the *Irish Builder*, and published therein, are, at the solicitation of many of my friends, now presented in more convenient form, without any pretension whatever to scientific research, or attempting to describe the different

combinations of stone ; and are intended, in the first instance, to promote, in preference to imported material, the more general use of native produce. Our limestones, marbles, and granite need no comment. The sandstones of Fermanagh, Monaghan, Tyrone, Derry, and Cork, and the freestones of Antrim and Derry, are fully equal, with the exception of Portland, to any in the British islands, and, therefore, ought not to be confined to a casual local demand—whether sufficient facilities are offered by quarry proprietors and railway companies, or that a prejudice exists against them, is not my province to inquire.

Secondly, for the purpose of encouraging a taste for the study of Geology and Chemistry amongst architectural students. That a knowledge of both is absolutely necessary to all who are practically engaged in constructive works will be admitted, as absence of information on these points frequently leads to disastrous results in the prema-

ture decay of the dressings and ornamentation of many a structure.

All stone of stratified origin, but, more particularly, the sandstones and freestones, require care and discernment in their selection, as well as the attention which should be given to their being set only in their natural bed of deposition.

Granite, although of igneous formation, and frequently described as the hardest of rocks, occasionally deceives the most experienced. The uppermost beds of all quarries, whether stratified or igneous, particularly if long exposed to atmospheric influences, are much more subject to disintegration than deeper strata ; therefore, stone from one part of a quarry may be most durable, while that which exists in close contiguity with it will prove to be the opposite.

It will be in the recollection of many, the rapid decay of the granite ashlar facing of the

arched entrances to the Four Courts, Dublin, which, after a lapse of little more than half a century was obliged to be almost entirely renewed, while the Portland stone dressings, apparently a much softer material, remained intact ; therefore, to guard against similar fatalities, of which we have numerous examples, a fair acquaintance with Geology and Chemistry is requisite—the one to determine the durable properties of the stone, the other to be informed upon the different oxides it holds in combination.

•

To supply this information is not attempted here, my object being to enumerate the different localities in which stone is obtainable, leaving its selection to more competent authorities.

In order to make these chapters more geologically complete, and possibly more interesting to the non-professional reader, I have included a notice of the coal formation and mining districts. For

the uninitiated, the entire has been written as a pioneer, to learn from standard authors, as well as from nature's page, one of the most interesting of all sciences ; and it is to be hoped that those who have studied in its higher walks will not look unfavourably upon my attempt to simplify its teachings.

WILLIAM HUGHES.

Talbot-street.

PREFACE TO SECOND EDITION.

THE demand for the first edition of this book has exceeded my anticipations ; possibly this may be explained by the favourable opinions expressed towards it by all sections of the press throughout Ireland. I am, therefore, induced to produce a second ; and in order to render the notes contained therein more complete, and the more familiarly to explain the origin of all mineral formations, I think it necessary to refer to the condition of the earth previous to the creation of man, as, beginning from this source, the rudi-

ments of geology are with greater facility rendered intelligible to those previously unacquainted with it.

The eruption of volcanic matter, the cooling down and subsidence thereof, the wearing away by the action of the atmosphere of these primary rocks, and the deposition of their *debris* under water, forming what is known as Sedimentary Rock, is perhaps sufficiently explained in the following chapters, and needs no special reference here ; therefore, I will only direct attention to the fact, that this planet has existed for indefinite time, long and long before the human race was called into existence ; and although, to some, the theory may appear not in accordance with Scripture, it, on the contrary, compels us the more fully to believe in it, and the more to reverence the power of that Divine Being who, through successive changes of this earth's surface, at length fitted it as the abode of His image, man.



These teachings many will consider not strictly orthodox, but it is to be remembered the simple Scriptural account of the creation was written not for the scientific but for the ordinary conception of the human race, and that it was altogether needless to inform them what previous changes had taken place in the world they were formed for. The six days of the first chapter of the book of Genesis may or may not be figurative, for it was equally in the power of Him who created all things to renovate the earth and its surroundings in hours much less in days; there are limits to all human knowledge, and this is one: the mind of man cannot grasp what is sealed from him by his Maker.

The stupendous works of the ancient Egyptians, their excavations for foundations of pyramids, their temples, their canals and tanks, their quarrying for the different materials used in the construction thereof, as also for their monoliths, only obtainable at considerable depths, afforded

them opportunities for geological information which few nations or peoples have had opportunity of ; hence it is not surprising they early became acquainted with the previous conditions of the earth. In modern works—railway cuttings, tunnelling, and mining explorations—far greater depths than the ancients ever contemplated have been arrived at, and have afforded much more extensive information than they obtained ; still it is singular that the discoveries of the present day are only confirmations of what has been taught considerably over two thousand years ago.

Egyptian cosmogony* was adopted by the Greeks, and engrafted upon the "Institutes of Menù," the sacred volume of the Hindoos ; but perhaps the pre-information of the latter was more particularly derived from traditionary accounts of the deluge and the volcanic eruptions occasionally desolating parts of Asia.

* "Prichard's Egypt. Mythol.," page 177.

That the age of the earth dates back so far into infinite existence as to seem to those who have studied its history an eternity of the past, is now agreed ; and also that it was in its earlier periods the theatre of teeming life, both vegetable and animal, over and over again renewed through successive terms of destruction and renovation, records of which are inscribed in indelible characters in the vast catacombs of fossil remains which present themselves to the view of the geologist ; while its flora and fauna, varying with each of these phases of its history—yet preserved so plainly, and presenting so faithfully lines of demarcation drawn between them as to make easily discoverable their different periods of existence ; while a retrospect of the time illimitable, necessary to produce them, not only teaches, but fully confirms the theory above given.

Thus geologists have discovered that, previous

to the creation of man, this earth, as mentioned in the accompanying notes, was subjected to repeated convulsions, that thousands of years intervened between them, and that each completely destroyed all vegetable and animal life, or, as geology calls it, "the flora and fauna" of former periods, until at length Divine wisdom fitted it for an abode, and created for it man.

It is ascertained with the greatest approach to probability, if not with exact certainty, that, since vegetable and animal life has existed, at least twenty-nine different destructions and reorganisations of the earth's surface have taken place, which consequently made various changes in the distribution of land and water: what was land in one geological age became the beds of seas in another, and *vice versa*; and to this geologists are indebted for being enabled to prove the former duration of the earth, and also to tell that four great convulsions preceded

the introduction of life on the surface of this globe.

The vast intervals of time which elapsed between each destruction of the earth's surface and its renovation are divided by geologists into six different periods, or ages, thus: Azoic, Palæozoic, Triassic, Jurassic, Cretaceous, and Tertiary, which are again subdivided into stages, and these stages contain the successive depositions of the mineral strata deposited during their periods.

The first, Azoic, as its name implies, is wholly destitute of all traces of organic life, and contains several groups of strata resting upon the igneous rocks, therefore it is concluded this formation was produced before life in any form existed upon the earth.

The second is called Palæozoic, in which the first traces of organic life in fossil remains appear; and in this five distinct stages, each containing different deposits, showing widely different ages

of existence, and different types of "flora and fauna" from those which preceded them.

In like manner the Triassic consists of two such stages, the Jurassic of ten, the Cretaceous of seven, and the Tertiary of five, making twenty-nine in all, each of these representing so many different renovations of the surface of the earth.

In the following pages I have exclusively confined myself to the original and great natural divisions of rock—as granite, slate, sandstone, limestone, and trap, all of which are subdivided into numerous varieties, either according to their contact with igneous matter, or from the age of their deposition, or the names of the localities where they most abundantly occur, but all these different groups are comprised in one or other of these stages, and it will be apparent that long periods intervened between their several formations, and also that all sedimentary rocks must

have been, age, after age the bed of the ocean, at one time upraised and forming dry land, at another depressed and covered over by the waters, and this process repeated again and again at various periods. Veins of igneous rock have violently protruded through them, forming conical and peak-like summits, or poured over them in tabular masses, thus accounting for the change of structure and total loss of all traces of stratification in many. These protrusions, where occurring with more than ordinary violence, have uplifted the strata overlying them, and formed the great mountain ranges of the globe, displacing the waters and producing new ocean beds, where previously had been dry land, destroying life in every form wherever their influences reached; and it is to be supposed—and is certainly within the bounds of probability—that, when man's period shall have been fulfilled, similar agencies will again destroy the earth, and, perhaps, the Creator of

all things will again repeople it with another race as far superior to man as he is to the baboon and ape who preceded him in former conditions and ages of its existence. For it has been thus throughout all time : the inferior orders of creation were the first called into existence ; new orders, age after age, succeeded them, each with more highly developed powers ; and as Scripture teaches this world of ours (of whose previous history we could form no conception except through geological discoveries) will be destroyed, it is no stretch of imagination, judging from analogies of the past, to think that it will again be the scene of life of far higher organization than we can form ideas of.

WILLIAM HUGHES.

Dublin.

NOTE.

IN referring to the creation of the world in the preceding, I have stated, "the six days of the first chapter of the book of Genesis may or may not be figurative;" however, it might be, days in this instance are not used exactly in their literal meaning, and could be interpreted as periods. There was a tradition extant amongst the Jews that, as the world was created in six days, and a rest appointed for the seventh, so it was intended by its Creator to last for 6000 years, after which it should enjoy a rest of 1000 years under the reign of the Messiah.

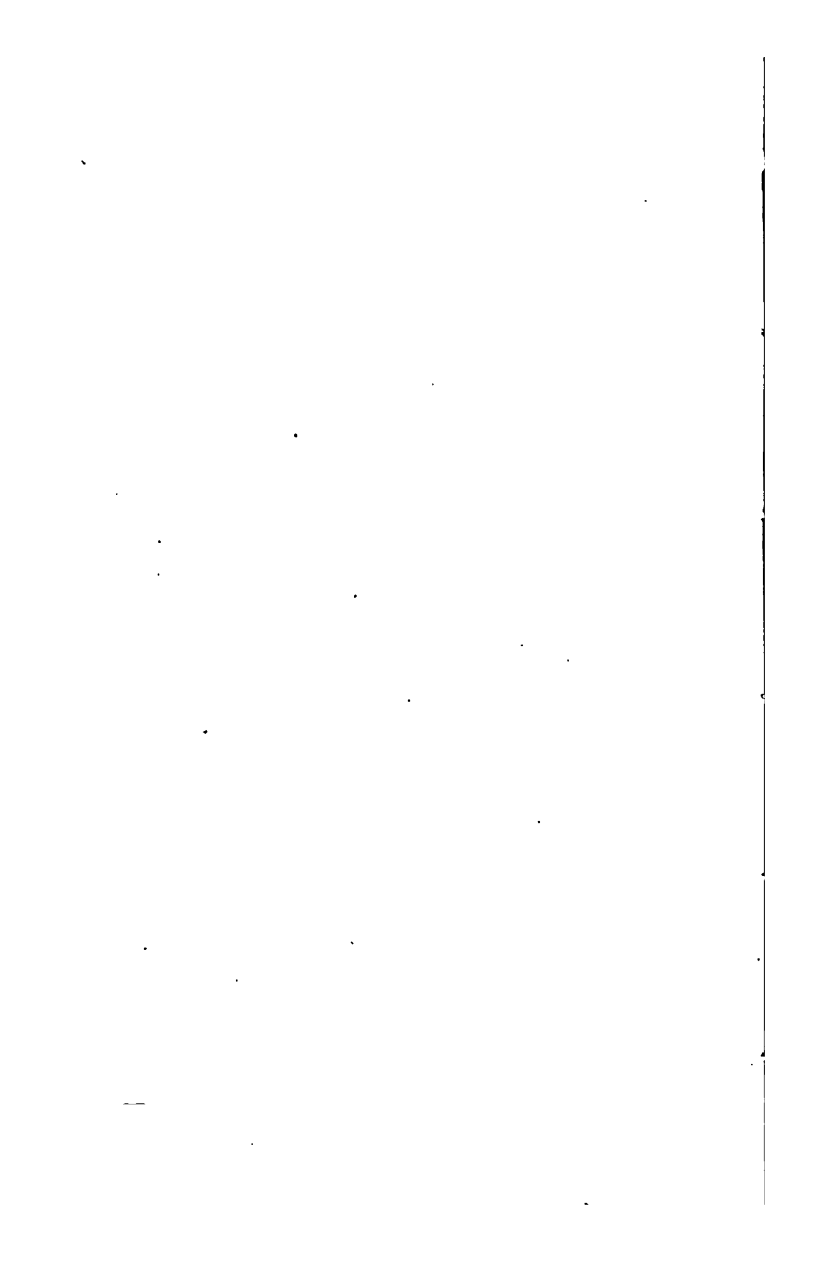
Many texts of Scripture tend to confirm this tradition; but with regard to the interpretation of the word "days," perhaps the most remarkable example is the following:

"But of one thing be not ignorant, my beloved, that one day with the Lord is as a thousand years, and a thousand years as one day." (2 Peter, iii. 8.)

W. H.

ERRATUM.

Page 35, line 3; for Aughanure, *read* Aughnanure.



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GEOLOGICAL NOTES.

GEOLOGICAL NOTES OF IRELAND.

CHAPTER I.

Preliminary Remarks—Strata—Theory of the Origin of Igneous Rocks—Deposition of Sedimentary Rocks—Distribution of Stone—Chalk—The Volcanic Rocks—Gypsum.

FOR the uninitiated inquirer in Geology the following pages have been written, and while they profess principally to treat upon the general formation and localities of Irish marbles and stone, as useful for constructive works, it is to be hoped that the information they convey may not be uninteresting to all who are anxious to become acquainted with the first rudiments of one of the most instructive and useful of sciences; more particularly to the student in Architecture, "The Sister of the Arts," they ought to be of importance, as giving a preliminary outline of the geological formation of the country which it is intended shall be the scene of his future action; and although, it may be, many of our young friends will possibly adopt other climes and other scenes in their future programme, yet to be acquainted

with the nature and composition of the building stones of their native country (as we hope to be enabled to give in these chapters) can scarcely fail to be interesting, particularly as practical geology, in its study, is uniform over the entire globe, and does not depend either on climatic influences or upon mere theory, the only differences being, that stone of one formation predominates more in one country than another, and that volcanic products preponderate in many.

Modern books of science, and more particularly geology, are generally abstruse, and abound so in technical terms that it is often difficult to arrive at conclusions from their reading. We will, therefore, adopt a plainer phraseology, and try to describe the Stones of Ireland in a manner to be easily understood.

In the first instance, our endeavour shall be to explain the primeval causes by which stone is produced, with a general view of stone districts; and then describe their different combinations, and enumerate the localities in which each kind, useful for constructive purposes, exist.

To examine a section of country in which its geological formation can be readily explained, is not often possible. True it is we have in the gorges of mountain torrents and in the cliffs of mountains sectional areas laid bare of greater or

less magnitude ; but these are generally so overgrown with tangled brushwood and fern as to be undistinguishable, except to the practical geologist.

In modern railway cuttings we have examples (although upon a small scale) of beds of different strata occasionally disposed horizontally, but generally inclined, in consequence of primitive rocks protruding through them. If it were practicable to arrive at a sectional cutting of the surface of a country which had never been disturbed, we would find it in the following order :—First, mould at the surface ; below it, beds of clay of varying thickness and tenacity, sometimes interspersed with boulders ; then sand and gravel ; underneath which, stratified rock ; and, beneath all, the primitive or igneous rocks. But a horizontal section like this could not be, from the constitution of the earth. The primitive rocks we generally find at the surface, and in most elevated positions. Modern geologists—amongst the rest, Dr. Lardner, in “The Crust of the Earth, or First Notions of Geology”—teach us the theory that this globe of ours was once a fluid mass in a state of igneous fusion ; that by degrees it gradually cooled down, and a crust was formed upon its surface, of which granite and other igneous rocks are the representatives ; and, when cooled down, that,

by condensation of the surrounding atmosphere, it became one vast ocean. Convulsion upon convulsion followed, by which mountain and dry land were reared over the surface of the waters ; and, if this be correct,* we must impute the formation of all other rocks to granitiform origin.

That countless ages elapsed during the formation of the successive beds of stratified rock, is apparent when we recognise the slow agencies by which similar effects are now produced. As we have before mentioned, the granitiform and other primitive rocks were first upheaved ; and as each convulsion necessarily produced corresponding changes in the disposition of the waters of the ocean, the dry land previously formed was overflowed and this with the disintegration and wearing away by the action of rain, together with frost and thaw in the higher altitudes caused the detritus to be carried away and held in suspension by water. The heavier particles subsided, and the lighter formed other deposits over them. These are the mica slate and clay slate rocks, the

* Scripture teaches this theory thus: "And the earth was void and empty, and darkness was upon the face of the deep ; and the Spirit of God moved over the waters" (Gen. i. 2). "God also said : Let the waters that are under the heavens be gathered together in one place : and let dry land appear. And it was so done" (Gen. i. 9).

first of stratified formation ; and we invariably find them bearing traces of combination with igneous matter. These were again upheaved and worn away in their turn, until they became the foundation of marbles and limestone, whose component parts are simply a deposit of terrestrial substances, with an immense intermixture of fossil product of marine origin.

The formation of sandstone is easily shown. It is the detritus of former rocks carried into the sea ; and any one standing upon a beach, beholding wave after wave depositing layers of sand, sees it going on at the present. It is only necessary that this beach should be submerged and subjected to the pressure of water to produce sandstone.

It needs no great stretch of imagination to prove, at a remote period of geological history, that Ireland was divided into two distinct islands ; and at a period further remote that it consisted of a series of islands, formed by some of the present mountain ranges ; and that these now form our most elevated districts is verified by the presence of ancient sea-beaches and deposits of marine shells approaching the summits of many ; while it is plain to the most casual observer, from the present appearance of the greater portion of the counties Galway and Westmeath, that the waves



of the Atlantic flowed for ages over them, the limestone formation cropping out upon the surfaces worn by wave marks, while the deposit of boulders with large and small stones of pebbly origin incontestably prove the former scene of an ocean bed.

Although time illimitable has since then elapsed, it may not be uninteresting here to show that numerous instances of the alternate elevation and depression of the earth's surface within historic times have occurred; but perhaps the most remarkable example is that of the Temple of Jupiter Serapis, of which three columns are still standing at their original full height upon the shore of the bay Baiae near Naples. There is sufficient evidence to show that the building—a quadrangular structure of forty-six columns in its original, the foundation of which can still be traced—stood some distance above high-water mark, and, from inscriptions yet remaining recording its embellishment, that it was erected at the commencement of the third century. In 1530 it is described as being covered by the sea; eight years later the coast line of Baiae was again raised twenty feet, with a tract of 600 feet in breadth, and the building re-elevated to its former position—(*Vide* Lyell's "Principles of Geology," vol. i. chap. xxv. page 522).

We cannot adopt the tradition so beautifully alluded to by Moore in the lines—

“ On Lough Neagh’s* banks, as the fisherman strays,”
because it has not been verified by modern scientific research ; but this tradition possibly may have some foundation in truth from the volcanic evidences of the entire of Ulster.

A great proportion of the elevated heights of Leinster, Ulster, and parts of the coast line of Galway and Donegal consist of granite ; the entire central and portions of the southern districts lying at a lower level are of limestone, occasionally interspersed with sandstone and numerous boulders ; while the southern ranges, with part of the south-eastern, are of sandstone and clay slate. Carrantoul, the highest mountain

* “ Lough Neagh is traditionally stated to have been formed by an irruption of the sea in the year 62 ; but it is obviously formed by the confluence of the Blackwater, Upper Bann, and five other rivers.”—Lewis’s “ Topographical Dictionary of Ireland.” That its bed and that of the adjoining lake (Lough Beg) may, at a remote period of Irish history, have been partially dry land, is not at all inconsistent with belief, because their only outlet is the Lower Bann, which is obstructed by weirs, many of them large masses of boulder carried down at remote periods by floods and deposited in its course. The ordinary level of Lough Neagh is forty-eight feet above the sea at low water ; Lough Beg is fifteen inches lower ; therefore an irruption of the sea without a depression of their present beds, of which we have no record within historic times, is not likely to have occurred.

in Ireland, is of the former formation; and so, also, are many of the mountainous districts of the west; while several of the headlands of Kerry, also Mangerton, Macgillicuddy, and the Glengarriff (Cork) mountains—presenting some of the boldest, most diversified, and picturesque scenery in this island—are of the latter.

We have not alluded to the chalk districts of Antrim, Down, Derry, and other parts of the north, generally superimposed by the igneous, trappean, and basalt rocks. Gypsum occurs in portions of this formation, particularly between Moira and Belfast, in which latter city it has been extensively used in the manufacture of plaster of Paris. Of these more hereafter.

CHAPTER II.

Tests applied to Stone—Granite.

SOME years since, Mr. Wilkinson, Architect to the Poor Law Commission, presented to the Economic Museum of the Geological Society of Dublin over six hundred specimens of building stones, representing every known quarry in Ireland, cubes of which he had previously submitted to a variety of tests in reference to their capabilities of resisting atmospheric influence, their relative absorption of water, their sustaining power with regard to crushing force, and resistance of transverse fracture. These, with the collection of marbles in the Museum of Irish Industry (now the Royal College of Science), St. Stephen's-green, Dublin (both of which are free to public inspection), afford a most valuable and interesting medium of instruction to all who are in connection with practical building.

Perhaps the most useful though not the most widely diffused stone is granite, fitted alike, according to the different localities whence it is derived, for the finest moulding purposes or the

coarsest rubble work. According to Lyell's description, it is "an unstratified or igneous rock, inferior to or associated with the oldest of the stratified rocks, and sometimes penetrating them in the form of dykes or veins. It is composed of three simple materials—felspar, quartz, and mica; and derives its name from having a coarse, granular stratum—*granum*, Latin for grain."

The districts where it occurs are always elevated (showing its igneous origin), and in parts of Ireland they are dignified as mountain ranges—as Dublin and Mourne—sometimes approaching the wildly picturesque, and forming marked features in the accompanying scenery.

Dublin bay is largely indebted for its attractions to the Killiney and Dalkey hills, as well as the background of the Three Rock range, while from an inland view their bold outline presents a pleasing contrast with the gentle undulations of the limestone formation.

Granite exists in considerable quantity in the counties of Dublin, Wicklow, Carlow, Down, Galway, and Donegal, and in the central districts, in isolated masses, either in small patches or in the form of boulders. The granite district of Dublin commences on the sea-shore at Williamstown, extending through Blackrock, Kingstown, Dalkey, Killiney, to Bray Head, stretching inland to

Golden Ball, Sandyford, and Dundrum, until it reaches the borders of Kildare. The Wicklow granite, which is a continuation of the Dublin formation, commences inside Bray Head, and passes at a distance of some miles from the sea-shore inland, until it approaches New Ross, in the county Wexford, extending in a parallel line bordering upon Kilkenny and into Carlow.

The Newry granite, as it is called, occupies portions of the counties Down and Armagh, and constitutes the greater part of the hills of Carlingford and the mountains of Mourne, which form so attractive a feature in the scenery of Carlingford Bay. The Galway granite commences at Galway, and stretches along the coast to Roundstone, its northern edge passing close to Oughterard, and including the islands off the coast. The Donegal granite, largely intermixed with quartz, stretches inland along the north-western shore for an average distance of eighteen miles, while its entire length is about thirty-five miles.

Granite varies greatly in quality and fitness for building purposes. In the county of Dublin, from the quarries of Dalkey, it is of an exceedingly hard nature, of a bluish tint, and difficult to work, but is a most endurable stone, and takes a high polish. At Golden Ball it is of fine grain, undistinguishable from the best quarries in Wicklow; while

towards Dundrum, it is coarse-grained, friable, and altogether unfit for any but the roughest work. The surface stone everywhere in the county near Dundrum, and further south, is largely intermixed with mica; the mountain streams, carrying it down in its disintegrated state, accumulate quantities of this glittering substance in their sand-banks. At upper Lough Bray the shores are literally composed of laminated beds of mica averaging the size of six-pence; we have often collected quantities of it. Wicklow granite, from its even and close texture, can be chiselled into every variety of moulding, and may easily be carved into Corinthian and Ionic capitals, particularly when they are of large diameter; but it is not to be recommended for the latter purposes, as the greater the facilities it affords the less enduring is the stone.

Carlow granite is celebrated for the facility with which it splits into long lengths, and small scantlings; also for its whiteness, easy working, and durability. All over the county, but particularly in the vicinity of Bagnalstown, fences of the simplest kind made of this stone are to be seen formed by the upright pieces sunk in the ground, with continuous lintels, averaging from 6 ft. to 9 ft. in length, laid over them, which require no fastening, as the weight of the longitu-

dinal stone keeps it steady upon the upright ; a quickset hedge is generally planted underneath, and it forms the most impervious of all fences. It is a beautifully close-grained stone, and can be worked into almost all ornamental purposes for building.

The granite of the Mourne mountains is of a flesh-red colour, easily wrought ; some specimens are bluish gray, and polish admirably.

A great variety exists in Galway granite ; some of it is coarse-grained, with a large intermixture of quartz, but it is generally suitable for ordinary purposes.

The quarries of Donegal have not as yet been sufficiently worked to pronounce a fair opinion upon the stone. It is coarse and very granular, with a reddish tinge, and generally soft and easily disintegrated. Where deeper workings have been effected, it is of strong but coarse quality, with quartz as its prevailing feature.

The tendency of stone to absorb moisture greatly determines its power of resisting the action of the atmosphere. As granite and limestone are the two principal building stones of Ireland, it may not be uninteresting to know how this property exists relatively between them, and which we are enabled to give from Mr. Wilkinson's experiments. The average weight of granite

is 170 lbs. per cubic foot, varying from 143 lbs. to 176 lbs.; and if immersed in water the Newry and Dalkey granites absorb $\frac{1}{4}$ lb., Carlow 2 lbs., and Donegal 4 lbs.

The average weight of limestone is 170 lbs. per cubic foot, varying from 159 lbs. to 180 lbs.; if immersed in water it absorbs but $\frac{1}{4}$ lb., its greatest absorption is $\frac{1}{2}$ lb., this tends to prove there are no varieties of granite superior in durability to limestone.

CHAPTER III.

Mica and Clay Slate—Remarkable Example of Mica Slate at Killiney; its distribution—Extent of Clay Slate Deposits—Roofing Slate; where Quarried; peculiarity of Cleavage—Quartz or Rock Crystal.

WE have given the theory of the formation of granite, the foundation and basis upon which all the other rocks have been erected; and we have shown how, by sedimentary deposit, layer after layer has succeeded each other, built up like courses of masonry by the Great Architect of the universe; and, as compared with all measures of time familiar to us, the formation of these successive strata must be counted back by periods illimitable, to which our knowledge of this earth's surface necessarily appears recent when contrasted with the historical data indelibly written upon it.

The mica and clay slate systems are the oldest of sedimentary deposit; but, before entering into consideration of any, it may be necessary to remark that each of these strata partake in a greater or less extent of the nature and character of the

rocks they are superimposed on ; and it is often difficult, sometimes impossible, to trace the beginning of the one and the ending of the other, and *vice versa*. This has given rise to numerous subdivisions of the different groups ; but to follow them would be unnecessary for the purpose of these chapters, besides extending them to far greater lengths than would be desirable. We will, therefore, confine ourselves to the description of the principal strata of each.

Mica slate, usually found resting upon granite, graduates imperceptibly into the clay slate which is generally found resting upon it. Although this rock is largely developed in Ireland, it does not occur to any great extent in Leinster. Commencing at Killiney, a remarkable example of mica slate—or mica schist, as it is called—exists in the cutting which forms the land side embankment of the Dublin and Bray branch of the Wicklow Railway. Midway between Killiney station and the mouth of the Dalkey tunnel a large extent of stratum largely impregnated with iron is observable, and it is thrown into every variety of position, from nearly horizontal to perpendicular, whence it extends in a narrow fringe edging the granitic districts by Bray Head through Wicklow and on to Wexford. In Mayo, Donegal, Derry, Tyrone, and Galway it is a most important rock,

as covering large surfaces ; but it is altogether absent in Munster. Clay slate is divided into two formations—the upper and the lower, and generally overlies mica slate ; but this does not always follow, as it is sometimes found directly resting upon granite. The lower division extends over an immense area in the counties of Cork, Kerry, Waterford, Wexford, Louth, and Down. The upper occupies the greater part of the south-west of Kerry, stretching into the adjoining county of Cork, and extends thence to Dingle Bay. The bold peninsular character of these districts, forming the magnificent bays of Bantry and Kenmare, with the picturesque heights of several of the Killarney mountains and the wildly beautiful scenery circling Glengariff, are altogether due to the natural formation of this rock. It is found in other parts of Ireland, but in limited quantity, as in Armagh, Tyrone, Derry, Donegal, Down, Clare, Wicklow, Waterford, Wexford, and Mayo.

Roofing slate has been quarried in Ireland with more or less success for a considerable period ; and, according as greater depths have been arrived at, the quality is much improved, some of it scarcely inferior to the best Bangor. It is found at Broadford, Ballagh, and Killaloe, in Clare ; Cahir, Begnish, and Valentia, Kerry ; Rathdrum Carnew, and Dunganstown, Wicklow ; Clonakilty,

and Kinsale, Cork ; Ross, Lismore, and Glenpatrick, Waterford ; Westport, Mayo ; Newtownbarry and Kilkeven, Wexford ; Letterkenny and Buncrana, Donegal ; Bangor, Ballywalter, and Hillsborough, Down ; and at Crossmeglen and Newtownhamilton, Armagh ; but the principal quarries are at Killaloe and Valentia. Sir Robert Kane states, in his "Industrial Resources of Ireland," that slabs of Valentia slate are easily obtainable 30 ft. long, from 4 ft. to 5 ft. wide, and from 6 in. to 12 in. in thickness ; and he appears to think it might safely be used in place of bearing timbers for the support of floors and ceilings of large rooms. This conclusion would seem to have been arrived at from its great resistance to transverse fracture ; but, calculating from its necessarily central specific gravity, we can hardly recommend the experiment being tried. There are specimens in the Museum of the Royal Dublin Society from Killaloe quarries of as large an area as 10 ft. superficial measurement, and this slate is largely used for roofing purposes. Valentia slate does not split so delicately as Killaloe ; it is therefore not as suitable for the finer qualities of roof slate, and is consequently more employed in the form of slabs and for flagging, for which the large dimensions it is obtainable in render it suitable.

A curious peculiarity exists with regard to slate rocks. Their line of cleavage is invariably at an angle different from their horizontal beds. All other sedimentary rocks split in the line which is known to have been that of their deposition ; but with slate this line of cleavage is at an angle differing from what was its original bed : hence it has been concluded that some great predisposing cause, as a large amount of subterranean heat, must have pervaded the entire system subsequent to the deposition and disturbance of their strata, which has had the effect of re-arranging their constituent parts in this peculiar manner ; and this is the more easily accounted for from their immediate contiguity to the granitiform rocks.

Clay slate is an important material in the numerous localities in which it occurs, because, where it will not split in laminæ sufficiently thin for flags or roofing purposes, it affords a valuable stone for ordinary building works.

Quartz, one of the constituent parts of granite, though not particularly useful as a building stone, may as well be alluded to here, as it is most generally found associated with the mica and clay slate formations, occurring in large veins protruding through, and in great beds cropping out on the mountain ranges of slate districts. It

contributes largely to the wildly romantic attractions of Connemara, forming the summits of some of its highest mountains, particularly Benabola, or the Twelve Pins, and also to the picturesque beauty of the Bay of Dublin in the panoramic view of the peninsula of Howth, with Bray Head and the Sugar Loaf Mountains, which are all capped with it.

In Wicklow it constitutes the extensive mountain range stretching from the Avonmore to the Vartry, and also Coolatin Hill, Shillelagh. In Wexford it is general throughout the county, occasionally met with of a deep red tinge, from its impregnation by oxide of iron. It is of pure white near Kilogue, and known as the white rock. It also forms the substratum underlying a large portion of the town of Wexford.

The surface stone of the north Island of Arran, in Galway Bay, is entirely of this formation. Flesh-coloured quartz in large veins permeate the granite districts of Armagh. It occurs in massive rounded boulders near the southern coast of Kerry and near Kerry Head, as well as in many other parts of Ireland.

Numerous beautiful specimens of quartz crystal are found throughout the island, perfectly transparent and occasionally of various hues, according to the colouring matter they have imbibed.

CHAPTER IV.

**Sandstone, Description of—Fossil Remains—Its Distribution in
Ulster, Connaught, Leinster, and Munster.**

THE sandstones are most widely distributed, occupying, in one form or another, almost every county in Ireland, and are, therefore, most important considered as building material. They are divided into two distinct groups—the old red and the new yellow; old and new comparatively, when considered in relation to the vastly different periods of their formation. But the term red is not literally correct, because this tinge prevails but in few instances, and arises, where it occurs, from a greater quantity of oxide of iron permeating through it than is general with Irish sandstone. Mr. Griffiths considers that the carboniferous strata of the county Cork should be considered a third formation. As this is an isolated strata, and does not occur in any other of the Irish counties, it may be better to recognise only the divisions above given. Conglomerate is sandstone in its coarsest form, and consists of

pebbles of different sizes cemented together with calcareous matter. Where the clay slate joins sandstone the texture of both becomes modified, and the colours and peculiarities of each are blended together, forming the material which is quarried as flags in different parts of the country.

There is no more interesting study in geological history than the sandstone formation—occasionally preserving the impressions of the most delicate plants, minute insects, shells, fossil fish, the foot-prints of aquatic birds, the rippled surface left on the sea-shore after the tide has receded, and the patten of the rain-drop, both vertical and oblique, showing the point of the wind whence its course had been directed—all these perfectly preserved in their sharpest outline; and in them we have records written in indelible type of by-gone periods and ages far removed from our time, yet so plain as to be identical with what is within our reach day after day. Limestone offers remarkable examples of fossil remains in its numerous preserved shells, &c.; so also does the coal formation, but in a different way; in the flora of past ages, reproduced to us in the most marvellously minute manner; but in no other but the sandstone formation can we so manifestly recognise the power of the Great Creator, completely and perfectly familiarized to our understanding.

As we have before mentioned, the distribution of this stone is very general; and, taking the provinces and counties as they occur from the map, we will commence with Ulster.

In the mountains of Donegal it exists in considerable quantity, resting upon limestone, and overlaid by granite, but being near their summits it is in an inconvenient position for use.

In Down, on the sides of Strangford Lough, for a length of about seven miles, it rises in some parts 350 ft. capped with green stone rising 150 ft. more; from these quarries the celebrated Scrabo stone is obtained.

There are also quarries at Kilwarlin, near Moira, where flags of considerable dimensions are raised, varying in colour from a light gray to a brownish red; but the quartzose sandstone of Fermanagh is a superior stone, being equal in durability and fineness of grain to any in the British Islands. Green sandstone, coloured by some metallic oxide, is general in Derry, and sandstone both of the old and new formation extends the entire length of the county, and surrounds its mountainous districts, stretching thence into Tyrone.

In the latter county the red sandstone occupies considerable portions of its southern and eastern districts, and is nearly equal to the Fermanagh stone.

In Monaghan it is found all over the county; and there is a peculiar and very beautiful white stone on part of Slieve Beagh, which is extensively quarried as being suitable for all architectural purposes.

In Antrim, as in Derry, a green sandstone is plentiful in the neighbourhood of Belfast. It also occurs near Carrickfergus and Larne, the underneath strata being red sandstone of a variety of degrees of fineness, in some places approaching to conglomerate, and in others of remarkably close texture; and this formation is found to prevail in the entire south-eastern borders of the county, and in detached masses along the eastern coast.

Armagh is more celebrated for its limestone; yet there is a beautiful close-grained quarry at Grange, where sandstone of every variety of texture can be obtained.

In Cavan, the Slieve Russel mountain range, forming the boundary between Ulster and Connaught, is occupied principally near their summits by the new red sandstone formation, and in many parts it forms perpendicular cliffs of great height, producing scenery of the grandest and most imposing character. The summit of one of these mountains is entirely composed of it, forming a large table-land, split up and traversed in every direction by enormous fissures.

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argillaceous sandstone flags occupying a bed of 200 ft. in thickness.

Isolated masses of sandstone are found in Longford ; and a considerable space at both sides of the Shannon is occupied by it, extending into the adjoining counties of Roscommon and Leitrim. It occurs in Wexford in greater abundance than in any other county in Leinster, a great portion of its coast-line, forming bold and abrupt precipices, is formed by it. In the inner haven of Wexford it is easily distinguished by its deep red colour.

In Munster, the entire range of the Roscrea and Devil's Bit Mountains, in Tipperary, are sandstone in mass, overlaid by conglomerate. So also are the Galtees. The lower range of Slieve-na-muck produces excellent flags of large dimensions, and extensively used for local purposes. In all the mountain districts of this county sandstone in great variety is obtainable ; it is also very abundant in Limerick, forming the hills of Knockaderry, Ballingarry, and Killmeady, and the mountains forming the boundary line between this county and the adjoining one of Cork.

Kerry is largely supplied with sandstone ; many of its mountains are entirely of this formation,

and eastward on the coast the sea-cliffs are exclusively composed of it. So also are the range of mountains which separate Kenmare from Bantry Bay.

In Cork extensive quarries are worked near Bandon, and also at Innishannon ; and it is found generally distributed throughout the county, but particularly along the coast line. The south-eastern angle of Waterford is entirely composed of sandstone.

CHAPTER V.

Oolite—Limestone; its Composition, Distribution, Durability, Upper and Lower Formation, Intermediary—Uses of Limestone—Calp—Chalybeate Springs near Dublin—What is Lime?—Mortar—Caverns in Limestone—Stalactite and Stalagmite—Travertin of Italy—Sulphate of Lime in Boiled Water—Marbles.

OOLITE, a carbonate of lime (of which the Bath and Portland stones of England are familiar examples), is found only in Antrim and Derry. Its name is derived from two Greek words, signifying the roe or ova of fish, which it is not unlike, being composed of small grains of sand closely cemented together by calcareous matter. Being easily worked, it is most useful for decorative purposes, and hardens by exposure to the weather; but it does not occur to any extent in Ireland. Like all other formations, it is divided into different groups, among which the argillaceous laminated stone called *lias* is found, which, from its fine-grained texture, is much used by lithographers.

Limestone, or carbonate of lime, is by far the most largely-developed rock in Ireland, and is

an accumulation of fossil remains of a scale of magnitude as vast and more recent as the primeval ages is almost to destroy our powers of belief. There are few instances in which these remains cannot be detected in rocks of more or less perfect crystalline sparkling or marble, it has lost its crystalline and is so that it has become crystalline—as in the great examples—from being subjected to the action of subterranean heat which has caused, obliterated the traces of such remains. The extensive information extends through the entire county districts, stretching from Fox Head to Inage north and south, and from Dublin Bay to Galway Bay east and west, and occupying a superficial area of over 10,000 square miles and there is no county except Wicklow where it is absent. Granite has often been described as the most enduring of stone, and this to a certain extent is correct, although applying only to limited examples, as we have already shown; but limestone, as a general rule, is a far more lasting rock. We have only to refer to the numerous remains of structures throughout the country in proof thereof, many of them still preserving their ornamentation in sharpest outline.

The limestone strata consists of three distinct *beds, formed at widely different periods in the*

history of the earth ; and these consist of the upper, the lower, and the intermediary, called calp. The lower formation is the most generally diffused, having been upheaved long ages ago through the other intervening stratified rock ; it varies in colour and in texture from the light gray crystalline (as at Sheephouse, Drogheda), the light blue (of Galway, King's County, and Carlow), to the deeper shades of calp, and the Galway, Kilkenny, and Carlow marbles, together with the beautiful variations of green, red, and yellow, until it eventuates in the purest white.

Carbonate of lime, either as limestone or in its different varieties of marbles, is the most important, the most useful, one of the most interesting, and possibly the most valuable production of Ireland, whether as considered in its appliances to agricultural purposes, its uses in arts, manufactures, and medicine, or as limestone in its various applications to building, either in the form of rubble stone, as the main constituent of the structure, the materials of the art-ornamentation which adorns it, or in its calcined state, the cement which consolidates it together, and which latter, if judiciously treated, restores it again as material to its original state.

Calp, or the intermediary formation, is limestone in its most impure state, nevertheless is

highly valuable for building purposes ; it is extensively developed throughout the country, but more particularly in Dublin, Cavan, Fermanagh, Leitrim, Roscommon, and Sligo. Wherever it occurs it is largely used for rubble work, and frequently employed as ashlar. It has one great defect—if not laid in its bed of deposition it speedily decays, falling away in laminated scales ; and this will continue even when covered by a cemented or composed surface, if exposed to atmospheric influences.

Calp is of much deeper colour, much closer texture, and considerably harder than ordinary limestone, but frequently of soft slaty formation, and occasionally shot with veins of crystallized carbonate of lime, which form the white streaks observed in this stone. Iron also exists to a small extent, and is sometimes seen in the form of pyrites, the glittering substances occurring in a few instances in some of its beds, as bisulphuret of iron, and it is from this source the chalybeate springs arise which occur in it. Several of these springs exist in the neighbourhood of Dublin, particularly in the valley of the Liffey ; and there was one many years ago at Portobello, which has latterly given rise to much discussion. But the disputants seem to be unaware that sulphuret of iron in a quarry is not inexhaustible ; the spring

may remain, but the vein it has permeated through may long since have been washed out.

The origin of limestone is very remarkable, and, as we have already shown in Chapter I., is a deposition of terrestrial matter carried down by rivers to the depths of the ocean, covering over the remains of shell-fish and coral animals, to which generation after generation had contributed their respective shares, where they arrived at great thickness and solidity, until at length they became hardened into rock by the infiltration of water holding carbonate of lime in solution, colouring matter being imparted to it by vegetable *débris* contained in the terrestrial matter above mentioned. But all these shells, &c., being composed of lime, and as they must have existed ages before what we now recognise as carbonate of lime was produced, the question naturally arises—What is lime? Lime, then, is an earth, the oxide of the metal calcium, and exists abundantly in sea-water; so also does carbonic acid, and it is generally allowed it is to the presence of both the formation of sea-shells is due, and to this source carbonate of lime owes its origin.

It is altogether unnecessary here to describe the process by which carbonate of lime is converted into hydrate or slaked lime; but it may

be of importance to remark that mortar used for building, if properly treated, and made with pure sand, will, from the slow absorption of carbonic acid from the atmosphere, be again restored to its original form of carbonate. We have numerous instances of this in the ancient buildings throughout Europe, but to those who feel an interest in this subject we refer to "Why Mortar Cements," given at the end of these chapters. We have stated that limestone is most durable; but a casual observer passing through districts occupied by it will form opposite conclusions in observing its water-worn aspect throughout the country. In the lower lake of Killarney this is particularly observable, where the stone has assumed every variety of fantastic shape, occasionally looking like gaunt spectral forms rearing themselves above the surface of its waters. But it is in subterranean rivers and caverns where its disintegration is shown upon a scale of vastness, which many will scarcely believe is occasioned solely by the solvent power of water. Carbonic acid will dissolve the hardest rocks, and every stream flowing through a limestone formation holds it in solution in considerable quantity; and, it is curious to remark, that the same power which produces limestone acts inversely, but only again to reproduce it upon an infinitely more extended

scale in the depths of the ocean. The limestone formations of Ireland entirely occupying its lower levels form the beds of numerous rivers, and every fissure in the rock which allows water to permeate becomes a source whence underground water-courses are maintained, if lower levels are accessible ; and in this way caverns are excavated in the solid rock, and rivers alter their courses underground.

We have many remarkable examples of subterraneous rivers, particularly in the county Galway. The drainage of Lough Mask into Lough Corrib is of this character. In the streams surrounding the village of Cong, which Sir W. Wilde, in his "Lough Corrib," page 161, thus alludes to : "There is water everywhere : gliding by in the broad river, gushing from the surrounding rocks, boiling up in vast pools that supply several mills, oosing through the crevices of stones, rising in the interior of caverns, appearing and disappearing where its wayward nature wills ; passing in and out everywhere except where man tried to turn it into the monster dry canal." Nature will not be cheated ; thus limestone districts always exhibit this peculiarity. Man cannot change what the Almighty Dispenser of the universe has otherwise ordained.

— Outside Oughterard, in the same county, the

river Feogh has percolated underground, and formed its course into Lough Corrib, passing underneath the ruins of Aughanure Castle.* There are numerous such instances throughout Ireland; but perhaps the most remarkable is that of the river Ardsallus, in Clare, which winds its devious way through the celebrated Tomines—immense caverns excavated by nature's hand, like vaulted tunnels, through the solid stone, their gigantic roofs superimposed over the river, while pendant stalactites of immense proportion, looking like huge Arctic icicles, meet you at every turn, the dim rays of light penetrating from the distance imbuing them with every variety of colour; although, from the metallic oxides they hold in combination, they need no reflected light; presenting, as Sir R. Kane observes, in his "Industrial Resources," "a scene of magnificence never to be forgotten by those who have viewed it."

* This Castle is situated about two and a-half miles south-east of Oughterard; and there is a curious story in connection with the river, which has formed a course for itself under its walls, which we have already given some years ago in a description of the building, but it may as well be repeated here. "Tradition tells strange tales in reference to this Castle. Our attention being directed to a trap in the floor of the dungeon-keep, we were informed that prisoners were consigned after execution through it to their last resting-place, by being lowered into the torrent underneath, where their bodies were rapidly borne off in the stream."

The caverns of Mitchelstown, on the borders of Tipperary and Cork, formed in the limestone rock, and covering an average surface in their various chambers of 700 ft. by 600 ft., exhibit the extraordinary power of this percolation of water; and again in its restorative qualities in forming stalactite and stalagmite, the magnificent columnar examples of these formations throughout these caverns almost defying description; the prismatic colours which they display by torchlight must be seen to be appreciated.

Stalactite and stalagmite are produced by water holding carbonate of lime in solution, percolating drop by drop through the overlying strata from the roofs of caverns in limestone districts, the stalactite hanging down like icicles; while the dropping underneath from which, when consolidated, is called stalagmite, the water evaporating, leaving behind successive crusts of carbonate of lime. Stalactite and stalagmite eventually unite, producing column after column, sometimes clustered and sometimes isolated, which, when hardened by age and absorption of carbonic acid from the atmosphere, produce variously-coloured stone, according to the mineral character of the veins the water which produced them has permeated through.

In volcanic countries petrification is produced in much shorter time than with us, the celebrated travertin of Italy (according to Lyell) becoming "a solid stratum of stone about a foot in thickness in four months;" it is hard and crystalline, and yet it is only a deposit from the water of springs holding lime in solution. Where these springs exist, a very beautiful and highly-interesting method is devised for producing works of art in stone. The streams containing the lime are diverted and made to pass over falls, so as to produce exceedingly fine spray. Moulds of suitable material are then hung within its reach, and after the lapse of a few days they are completely encrusted in stone, with every line as perfectly drawn as in the original,

Before the introduction of the Vartry system into Dublin, the incrustation of lime in vessels used for boiling water was well known, forming a solid mass, which, after a short period, became almost impossible to remove. The canals which supplied this water, running through limestone districts, held a large quantity of carbonate of lime in solution; also sulphate of lime, from the springs rising through the calp formation in which portions of their courses lay; being afterwards exposed in the city basins they imbibed sulphuric acid from the smoky atmosphere; and it is pos-

sible that these incrustations, if collected, could have been converted into Paris plaster.

Referring to marbles an immense variety exists, and in the west of Ireland particularly there is no lack of quantity, which the following extract from Dr. (now Sir Robert) Kane's "Industrial Resources" fully demonstrates; but, unfortunately for the country, foreign marbles are to be had in abundance, while the native material cannot generally be obtained manufactured. In this we must except the celebrated Galway (black), and in a lesser degree the Connemara (green), for both of which there is considerable demand; and we are happy to observe that within the last few years a considerable impetus has been given to the manufacture of Irish marble.

"The limestone districts of Ireland contain numerous beds, which the closeness of texture and the purity or variety of colour render available for ornamental purposes as marbles. I shall only enumerate the localities in which the most remarkable marbles are found. There is no county which does not afford specimens of greater or less excellence. The principal quarries of black marble are those of Kilkenny, and near the town of Galway; these are both in the upper limestone. The Kilkenny marble takes a beautiful polish, and when first cut is quite black; but the organic

matter to which its colour appears to be due gradually passes off, and ultimately white marks of fossils of varied and interesting forms present themselves upon its surface. The Galway marble quarries are situated along the verge of Lough Corrib ; they supply a large quantity of marble annually to London and New York, but are capable of almost indefinite development. Near Armagh is found a marble which, from the excellence of its surface, and the variety of red, yellow, and brown tints which it shows, possesses great beauty ; it contains abundant remains of fossil fish.

“ A similar marble, elegantly variegated with yellow and purple, occurs at Churchtown, in Cork, which county is indeed rich in this material, there being found black marble at Churchtown and Doneraile. Purple and white, and blue and white marbles also at Churchtown ; ash-coloured, gray, and dove-coloured marbles at Carrigaline and Castlemary ; pale brown marbles at Kilcrea.

“ In Kerry there are black and white variegated marbles near Tralee ; and in the islands in the river Kenmare, near Dunkerron, marbles of various colours—black and white, purple, white, and yellow, and some specimens of a purple colour veined with dark green, resembling blood-stone.

"At Craigeleith, in Down; at Lyons and Ballysimon, in Limerick; at Westport, in Mayo; and at Castlebegs, in Tipperary, are quarries of black marble. At Clondeslough, in Clare, a fine bourdella marble. Near Shannon-Harbour, on the Galway side, fine sienna and dove marbles. At Clonmacnoise, King's County, and Dromineer, in Tipperary, are fine gray marbles variously tinted, and peculiarly sound and useful. At Killarney occurs a very beautifully striped white and red marble; and a brownish red, mottled with gray of various shades, at Ballymahon, in Longford.

"The primitive limestones of Connemara and Donegal supply white marbles, which in Galway is often absolutely pure in tint, but in Donegal it is more frequently of a grayish cast. The Galway marble has been already noticed as the strongest of limestones when used for building.

"The west of Galway and Mayo is also remarkable for the serpentine rocks, which afford the beautiful variegated green and white marbles so deservedly esteemed; the most valuable quarries of this remarkable mineral are situated near Clifden, on the estate of Mr. D'Arcy. This marble is exported in considerable quantities."

Large quantities of continental marbles are imported into Ireland, many of them very

inferior to what can be produced at home. We have often stood in amaze looking at the numerous quarries of Galway, particularly in the neighbourhood of Oughterard, where, if easy access to the water carriage of Lough Corrib were available, mines of inexhaustible wealth would be made accessible.

CHAPTER VI.

Trap Rock—Basalt : General Remarks upon—The Giants' Causeway—Columnar Form : Description of—Sculptures—Greenstone—Chalk : Variation of, into Marble—Flint—Gypsum—Boulders—Shells and Marl—Sand and Gravel Ridges.

VOLCANIC rocks are designated by the name Trap or Trappean, and are found in the form of veins protruded through or overlying other rocks in tabular, columnar, or horizontal masses. The term trap is derived, according to Lyell, from the Swedish word "trappa," signifying stair, because rocks of this class frequently occur in terrace-like masses, rising tier over tier above each other, as gigantic steps of a staircase. A remarkable example of this kind of formation exists on the road about midway between Galway and Oughterard.

Viewing these rocks generally, they would appear to be of comparatively recent formation ; we may, therefore, infer that, in the earlier periods of the condition of the earth, circumstances were not favourable to their development, or at least to their propulsion to its surface.

Basalt, which is the most widely-distributed stone of this class, is now acknowledged to have been produced as lava, either from submarine volcanoes (in which case, cooling under the pressure of water, it became crystallised in columnar form, and was afterwards gradually raised), or it was poured forth at a higher level in tabular masses, covering the surfaces of other rocks. This formation is of very extensive occurrence all over the globe; the greatest known mass is that noticed by Colonel Sykes, and published in the "Proceedings of the Geological Society" (London, 1833), as existing in the Deccan (India), covering many thousand square miles of surface.

On the continent of Europe, in Italy, central France, and upon the banks of the Rhine, also in Iceland, and in the Hebrides (at Staffa), we find imposing examples of columnar basalt; but in no region of the globe is the majestic grandeur of the formation of the north-east coast of Antrim equalled, where, according to the accurate measurement made by the Ordnance Trigonometrical Survey, many of the columns reach as high as 317 ft., and the sides of these enormous prisms occasionally measure from 5 ft. to 6 ft.

The stones of the Giants' Causeway, jointed concave and convex one into the other, and fitting with the utmost accuracy in their polygonal sides

—within the interstices of which the blade of the smallest penknife cannot enter—are justly considered a phenomenon of nature; but visitors to this district seldom take the trouble of viewing the miles upon miles of coast-line, only seen from the sea, stretching towards Belfast, where the columnar formation shows itself in heights, including the chalk beds upon which they rest, and their superincumbent capping, rising from 500 ft. to 600 ft. in perfectly perpendicular lines, forming the most magnificent coast-line in the world.

This stone principally occurs in Antrim and Derry, both columnar and massive; it is also found in considerable quantity in Limerick, and it is seen in some of the hills, massive, in Kildare, as well as in other inland districts.

Basalt is a close, compact rock of dark green colour, nearly approaching to black; it is of variable composition, and consists principally of silica, oxide of iron, alumina, and lime. Silica and oxide of iron exist generally in the same proportions in it; but alumina and lime—both of which largely modify its texture, the former varying from one to six, the latter from one to nine in its quantity—alter its structure to a very considerable extent.

Lyell informs us that “many of the figures of Egyptian temples are formed of basalt;” there-

fore the stone from which they were sculptured must have contained alumina and lime in vastly greater proportion than occurs with us.

Greenstone, popularly called whinstone, occurs in all the clay-slate rocks, and frequently in sandstone; it is of volcanic formation, protruded through other rocks of sedimentary deposit, of hard, compact nature, of exceedingly close texture, and as an ordinary building stone it is useful; but is not obtainable in sufficient quantity in Ireland to demand especial notice here. Wherever it occurs it is used as rubble stone, and occasionally in the form of ashlar; but the difficulty of working it, except as hammered stone, precludes its use for the latter purpose to any extent. There is a bridge in the county Wexford entirely built of it. It is found in the east of the county Limerick, also in Down, Antrim, Derry, and Donegal, and, like all volcanic rocks, it alters the character of other formations where it comes in contact with them. It obliterates the stratified appearance of the sedimentary strata, and causes them to become crystalline. Blue limestone is occasionally converted by it into a close-grained white marble.

Chalk exists in considerable quantity in the counties of Antrim and Derry; the basis of the entire north-east coast of the former county is

composed of it, and it stretches to a considerable distance southwards. It is upon chalk rock, which presents a characteristic feature in the abrupt prominences of the sea-board line stretching from Strangford Lough and beyond the romantically-elevated Castle of Dunluce,* that the columnar basalt rests. In many of the mountain districts of Derry, chalk crops out on the acclivities, capped by massive basalt. Along the Portrush coast it is well developed, and many interesting examples are seen in the white rocks of Dunluce. Being more useful in an agricultural point of view than in connection with building, this formation does not require particular attention, except where veins of trap have been forced through it, when it is converted into limestone generally of a crystallised texture and considerable hardness, and this to a large extent on both sides of the invading vein.

Dr. Berger (Geo. Trans., 1st series, vol. iii. page 172) thus writes in allusion to these veins:—
 “The extreme effect presents a dark brown

* Underneath the Castle of Dunluce is an immense cavern, excavated by the continuous action of the sea on the chalk formation upon which the superincumbent basalt rests; and there is a tradition attached, that part of the floor of one of the apartments over this cavern suddenly gave way, upon the occasion of a festival given by the Lady Margaret M'Donnell, and that the occupants, with one exception only, were precipitated into the sea.

crystalline limestone, the crystal running in flakes as large as those of coarse, primitive limestone. The next state is saccharine, then fine-grained and arenaceous, a compact variety, having a porcellaneous aspect and a bluish gray colour, succeeds ; this towards the outer edge becomes yellowish white, and insensibly graduates into unaltered chalk."

Flints occur in numerous instances throughout depositions of chalk, and when examined by high microscopic power, they are invariably found to include traces of animal life—some of the zoophytes, perhaps a sponge, in which silica has been deposited and accumulated.

Chalk, though highly absorbent of water, possesses the property of not permitting fluids to permeate through it ; and it is in consequence largely used for the purpose of lining ponds and reservoirs. If a little salt be added, to prevent worms boring through, it forms the most effectual possible puddling for canals, water-works, &c. Of course these remarks are only applicable to districts where chalk can readily be obtained, as the cost of carriage would act as prohibitory to its use at considerable distances.

Gypsum, or sulphate of lime, is lime combined with sulphuric acid, the origin of which is sometimes disputed ; however, it is now acknowledged

as with regard to the white marls of Montmartre—the largest known accumulation—(the Paris basin) that gypsum is a fresh-water deposit, but largely intermixed with calcareous marine matter, occurring, as we occasionally find it, in the course of a river being cut off in its connection with the sea, either by an elevation of the coast-line, as at Baiae, Naples, or in a more familiar way by the constant action of the tide elevating a beach.

A few miles from Dublin there is a small mountain river, which delivers itself on the shore close to the Ballybrack station (Dublin, Wicklow, and Wexford Railway), having no apparent outlet, the tide continuously washing up sand in its course ; and the river water (except in the case of floods, when it forces itself through the obstruction) has no escape except by percolating through the constantly-recurring barrier of sand raised against it. During the prevalence of high tides the estuary of this river becomes a salt-water basin ; and, if its course lay through a limestone district, gypsum would form in considerable quantity therein.

Rounded water-worn masses of stone—many of diameters of twenty feet, principally of granite, but including every known formation—are found all over the country, often in such elevated positions that it is matter of surprise how they have

been transported thither, because, being generally of different stone from that which occurs in the locality (although this remark does not always follow); sometimes in an exclusively limestone district we meet granite, conglomerate, sandstone, and trap rocks, lying within a few yards of each other, all rounded by attrition with other rocks.

It is now acknowledged it is from the floating power of ice we have derived these immigrants to our shores—some of them from the loftiest Alpine regions, many from the coasts of Greenland and Labrador. Yet several are native, but invariably of granite, and most generally found embedded in clay deposits, some of them projecting partially above ground, others covered but by a few inches of soil, while numbers are excavated at considerable depths—these are derived from the Donegal and Mourne mountains, and the Killiney and Dalkey hills, and could only have been deposited in their present positions when this country was largely under the influence of water.

In northern latitudes enormous icebergs are constantly found floating, many of them rising some 200 ft. to 300 ft. above the sea level, and having much greater depth under water, in which are embedded huge rocks, clay, and gravel;

and, as they float into warmer latitudes, the ice melts, and deposits this foreign matter (which may have travelled thousand of miles) at the bottom of the ocean. In after ages this ocean bed is gradually upraised, covered by numerous masses of rock. To the student in geology, Galway county offers the most interesting examples of immigrant boulders.

In our previous remarks we stated the theory that Ireland was at one period almost wholly submerged under water. Beds of shells covered by marl, but always found resting upon gravel, numerous occur all over the country, in basins on the slopes of hills, but more generally in valleys. These shells are univalves and bivalves, whose habitât is the deep sea or upon the slopes of a shore ; and they have become in their present positions covered over by successive deposits of a calcareous marl, only produced by the subsidence of water holding lime and clay in solution. In many instances they are discovered under a considerable depth of bog. It is in this marl that Griffiths describes the skeletons and horns of the Irish elk being found, fine specimens of which are preserved in the Royal Dublin Society's Museum, and in the Royal College of Surgeons. This animal, whose remains have been excavated in abundance in these deposits, appears to have

been a contemporary with man, as a human skeleton has been found embedded in the marl closely adjoining one of them. Along the eastern coast of Ireland, as well as in many other portions of the country, fine sand and beds of sea-shells are found at considerable elevations above the sea level—in many instances as high as 600 ft., which is still more conclusive of the theory above given.

The sand and gravel hills of Ireland form a most valuable adjunct to building material. As Eskers they are known in every county, their substrata being beds of clay, then gravel, superimposed by sand, frequently containing marine shells. Sometimes all these deposits appear to have been violently mixed together by some disturbing action. In the county Dublin we have examples in the Green Hills, near Tallaght, but they occur everywhere all over the country; the great majority, however, are found in the central limestone districts. These sand and gravel ridges confirm our knowledge that Ireland was, at a comparatively recent period in geological history, covered by water; also that by gradual elevation and consequent subsidence currents were established, and, where meeting with obstruction, they deposited these beds of clay, gravel, and sand.

From Dr. Antisell's "Irish Geology," page 73, we extract the following :—"These hills are looked upon as deposits out of diluvian currents, which swept across the country in a direction in some degree N.W. and S.E., but altered in many cases by local obstructions. It would appear that the currents were sometimes of great depth and of varying velocity, for many of the beds bear marks of violent agitation and unequal subsidence, mixing all the contents together without regularity ; while in others, the evenness and succession of the beds, and the finer lying conformably upon the coarser, indicating that in the last the waters were in a state of quiescence compared to where the deposits are uneven."

CHAPTER VII.

The Coal Formation—Mining Districts—Conclusion.

THE coal beds and mineral veins of Ireland do not properly belong to the purpose of these chapters, but being commercially of considerable importance, and most interesting in a geological point of view, our subject would be incomplete without some notice of them. Their extent and localities have been described in Mr. Griffiths' "Outlines of Geology of Ireland," and their commercial value prominently brought forward in Sir R. Kane's "Industrial Resources," to which authorities, for information on these points, we refer our readers.. Coal always occurs in seams of different thicknesses, overlaying each other; seldom horizontal, but generally inclined, as all deposited strata are found; its being of vegetable origin is unquestioned. At the period of its accumulation, that the earth was covered by rank, luxuriant vegetation, and a nearly tropical heat pervaded the entire surface, is believed, because the remains of tropical plants, such as tree-ferns,

most predominate, while many of the species discovered are totally unknown at the present day, yet all evidently of tropical growth.

In the shale which separates these beds of coal, and in the sandstone accompanying them, impressions of plants are found—horse-tails and club mosses of enormous size, yet bearing evidence of being allied to the diminutive specimens existing in our climate, but of such vast proportion in their cellular structure as to prove they could only have existed in very warm latitudes. Numerous large fragments of trees are found upright, with their roots still embedded in their native soil, while many more are horizontal, as if transported from a distance.

The most probable theory accounting for coal beds is: that they were once immense tracts of the richest vegetation, of which we have now no representatives, except upon a small scale, in the swamps of India, Africa, and South America. We have sometimes heard that our own bogs will, after the lapse of ages, be reproduced in the form of coal; but of this we must remark, when that period shall arrive they will be found greatly deficient in the properties of our present product. The luxuriant vegetation of tropical climates can only produce it, such as we are stomed to.

But to return. These enormous fields of vegetation—the vegetation of age after age, superimposed upon each other—were, by some depressing cause, lowered until they became submerged under water. Possibly by being thus formed into the beds of lakes, they accumulated mud and sand, which formed successive strata over them. They were again upraised, similar vegetation appeared, and similar results followed.

We cannot better terminate our remarks upon the formation of coal than by giving an extract from Professor Buckland's graphic account of the coal mines of Bohemia, given in Bridgewater Treatise :—"The finest example I have ever witnessed is that of the coal mines of Bohemia. The most elaborate imitations of living foliage upon the painted ceilings of Italian palaces bear no comparison with the beauteous profusion of extinct vegetable forms with which the galleries of these instructive coal mines are overhung. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of most graceful foliage flung in wild irregular profusion over every portion of its surface. The effect is heightened by the contrast of the coal-black colour of these vegetables with the light groundwork of the rock to which they are attached. The spectator feels himself transported as if by en-

chantment, into the forests of another world. He beholds trees of forms and characters now unknown upon the surface of the earth presented to his senses almost in the beauty and vigour of their primeval life. Their scaly stems and bending branches, with their delicate apparatus of foliage, are all spread forth before him, little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation which began and terminated in times of which these relics are the infallible historians."

Lyell does not give the formation of coal, but, in Vol. II., "Principles of Geology," page 249, he describes the drift-wood constantly floated down large rivers into lacustrine deposits as now producing wood coal. In Ireland we have examples of this in the lignite found on the banks of Lough Neagh, at depths varying from 30 ft. to 70 ft.

In connection with the formation of coal, it is an extraordinary fact that, no matter in what part of the world it is discovered, even at Melville Island, in the regions of eternal frost, the same tropical vegetation pervades it. This would tend to show that the climate of the entire globe was at one period uniform; however, geologists disagree upon this point, and as yet no satisfactory explanation has been given.

The coal formation of Ireland rests upon the upper limestone, with intervening beds of sandstone and slaty rocks, and the districts where it occurs have generally an aspect of considerable elevation. A glance at Sir R. Kane's "Geological Map of Ireland" will at once show where all the workable seams occur.

Mining operations date back to a remote period. In several of the abandoned workings of former times, antique tools are found, wooden shovels, stone hammers, and chisels of primitive form, evidently of great antiquity.

Dr. Boake tells us in "Natural History of Ireland," written more than 230 years ago, that iron was manufactured then in considerable quantity, so much so as to have been an article of considerable export to London. Iron ore exists largely in numerous places, and is found in almost every coal district. There is also what is called bog-iron ore, which, as its name implies, occurs in bogs and morasses. Iron ore is also found in the sandstone and clay slate deposits.

In the clay slate, copper is obtained more or less abundantly, particularly in Wicklow, Waterford, and the southern portions of Cork and Kerry.

Lead ore is extensively developed in the granite districts of Dublin and Wicklow. Near Dublin,

at Clontarf, in the calp formation on the sea-shore, it was for a time successfully raised, until the tide broke in and filled the mine with water. In the clay slate deposits it occurs in Armagh, Down, and Louth, and in Clare, Cork, Kenmare, Kilkenny, Waterford, and Wexford, in the granite and mica slate of Connemara and Donegal.

Silver is generally found associated with lead in Ireland, and varies in quantity from 8 oz. to 120 oz. per ton of ore. At Kilbricken mine, in Clare, it occurs in the latter large proportion.

That the ancient Irish must have been possessed of native gold is evinced by the abundance of their ornaments preserved to our time, and for which no means of importation then existed. About eighty years ago considerable quantities of gold were found in the beds of the streams which descend from the mountain Croghan Kinshela, which rises on the confines of Wicklow and Wexford, where it was for a considerable time collected by the peasantry in larger and smaller nuggets, and even down to the most minute grains. The business of its extraction was at length taken up by the Government, but it was found after a while it would not pay the cost of working. About forty years ago a London company obtained a lease of the district, but the produce of gold was so trifling the works

were finally abandoned. Yet it is curious to remark that, before the Government had possession of the mines, reliable information informs us a sum of £10,000* was realised by the country people who collected it.

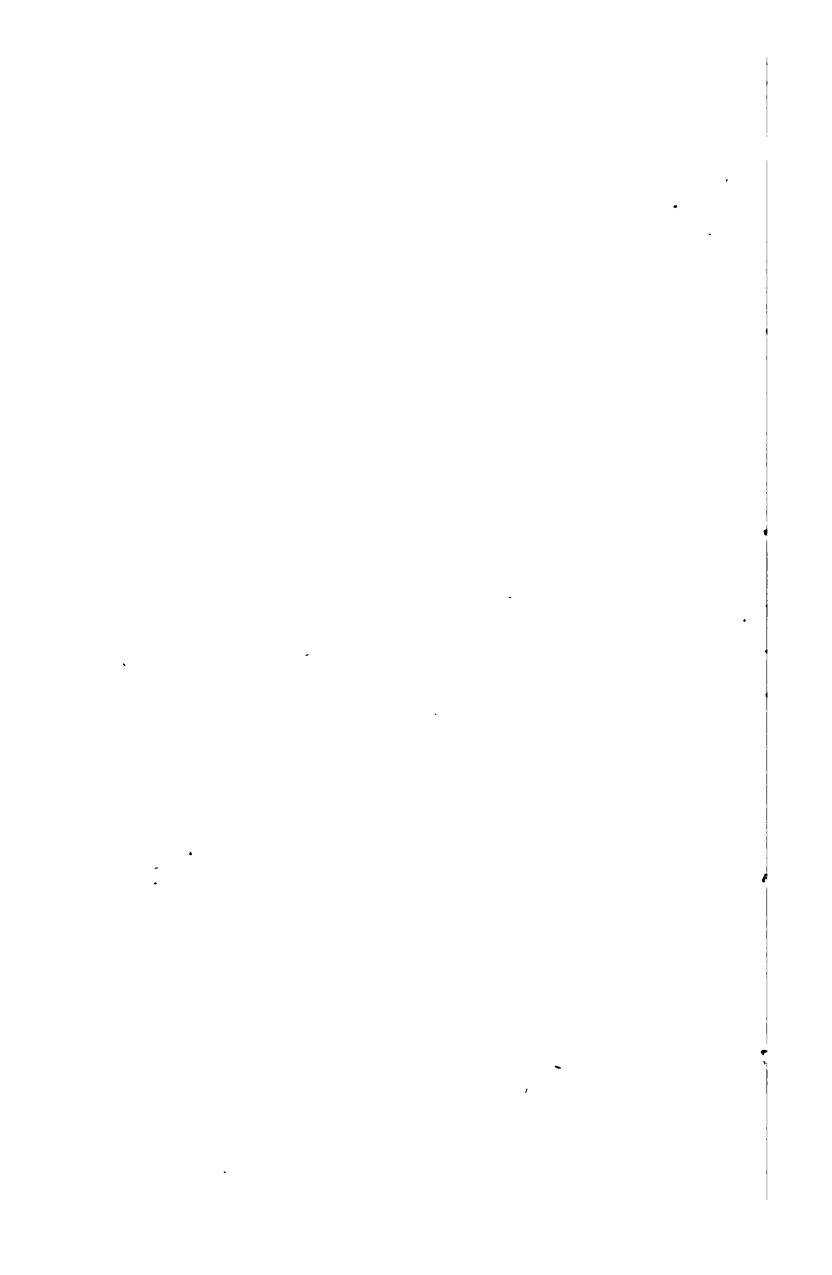
Iron pyrites, or sulphur ore, exists in considerable quantity in the clay slate of Wicklow, and is an article of constant export.

In concluding these chapters, our only remarks shall be—we have avoided, as being unnecessary for their intended purpose, entering upon the numerous subdivisions of stone so minutely described by geologists. All formations—either granitic, stratified, or volcanic—where, as they necessarily must be, in contact with each other, produce numerous hybrid variations, completely altering their relative textures, each partaking of the qualities of the other, the igneous rock becoming partly stratified, and the stratified losing the primary traces of its origin. These natural changes have contributed largely to subdivision, while many of the different groups derive their names from the localities in which they most abundantly crop out on the surface of the globe; others from the organic remains, either animal or vegetable, found imbedded in them; but by far the largest

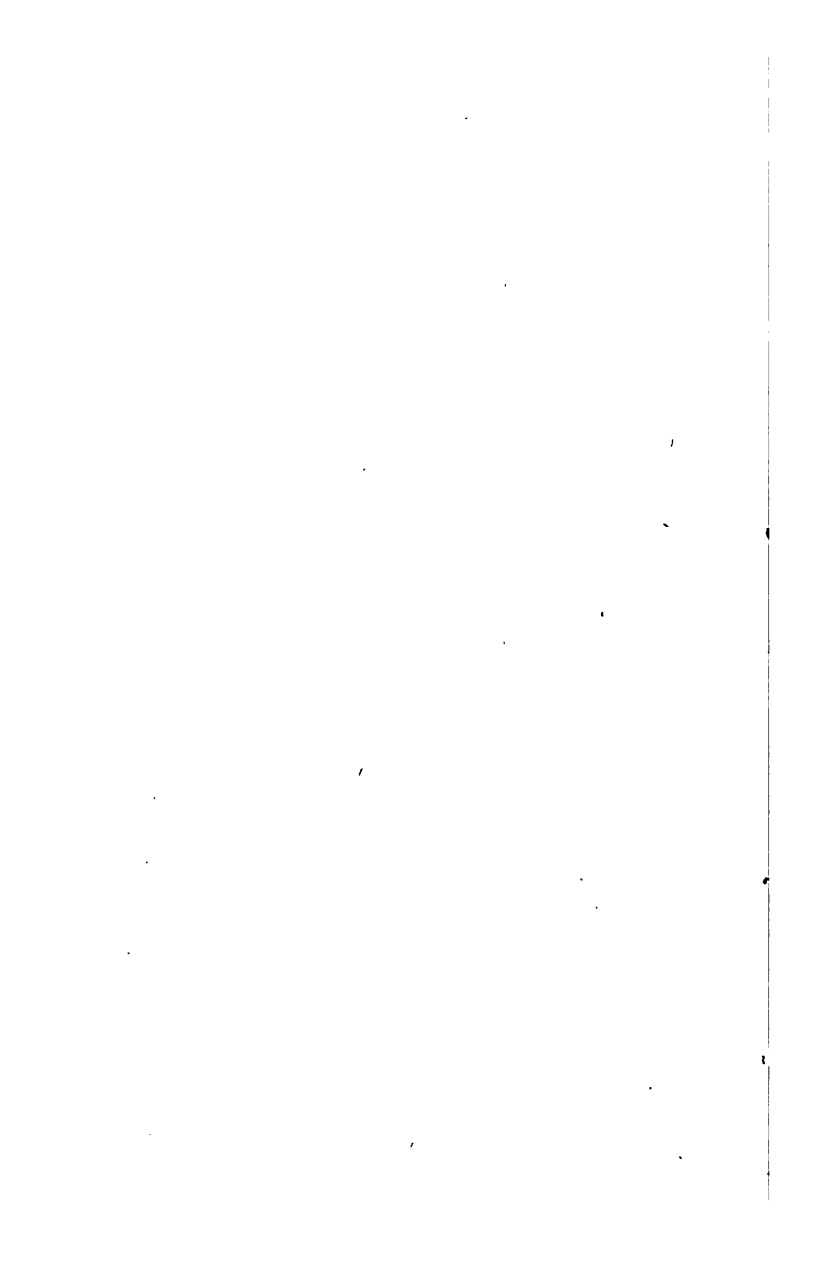
* "Industrial Resources."

are classified from the age of their deposits, to which a puzzling Greek nomenclature is applied. Our purpose has been to explain in the simplest possible manner the different descriptions of stone suitable for building works as occurring in Ireland, therefore we have confined ourselves to the principal denominations of each, avoiding altogether entering into minutiae, which, in a utilitarian point of view, could have no connection with our subject. In remarking upon the coal formation, and mining districts, the information given is only of a general character. Both are ably treated, and in the fullest possible manner, in the works of Mr. Griffiths, and Sir Robert Kane of whose valuable labours we have availed ourselves, in addition to other acknowledged authorities. In these chapters we have had but one object in view, namely, the promotion of a taste for geological information, which many erroneously suppose is inconsistent with Divine teaching. When it is remembered that the revelations of Scripture are more generally employed in a figurative sense, the first chapter of the book of Genesis will be found only to explain the truths unfolded by science, and make apparent the dispensations by which the Almighty Architect of the Universe, in the exercise of his Divine power, has rendered this earth subservient to all the

wants of man ; and as each phase of geological discovery presents itself to our view, in page after page of its history, they in their turn tend the more fully in compelling us to acknowledge there is no departure in them from the words which have emanated from the Great Creator of all.



APPENDIX.



APPENDIX:

WHY MORTAR CEMENTS?

WE are often asked the question, "Why some mortars harden, while others never do?" Every builder's labourer knows what are the component parts of good mortar, but every one is not acquainted with the chemical changes it undergoes, or the conditions necessary to produce it. Mortar, to be durable, must be composed of silica, or sharp sand, and hydrate of lime, or what is commonly called slacked lime; the absence of all loamy particles is necessary to make good mortar, yet we often find a bad cement is produced when both lime and sand are of the best quality.

The induration of mortar is produced by the gradual conversion of hydrate of lime into carbonate of lime, and is effected by the slow absorption of carbonic acid gas from the atmosphere, and this continues so long as any particles

of moisture remain in the mortar. The more slowly this process is carried on the better becomes the cement ; hence we find that the mortar used in walls built in very dry weather is never so good as the same mortar used when the atmosphere is moist, because, in drying too quickly, the carbonate is not either formed at all, or, if it is, it remains so much divided it cannot acquire the necessary adhesive properties. On the other hand, if exposed to too much wet, portions of the lime gradually dissolve, and what remains is converted into carbonate with great difficulty, the particles of sand becoming isolated. Therefore, if mortar in a wall can be kept moderately moist for a sufficient time, the carbonate acid gas acts slowly but incessantly, and the water contained in the mortar becomes gradually saturated with it ; this acting upon the lime, it is converted into carbonate in successive portions, and produces the best mortar. With clayey sand—or, as we often find in suburban buildings, clay used as sand—this conversion into carbonate of lime becomes impossible, because there are few or no particles of silica for the lime to grasp ; it is therefore reduced into a substance which pulverises to the touch. The opposite takes place during frosts, even where the sharpest sand is used, because the expansion of the water arrests the

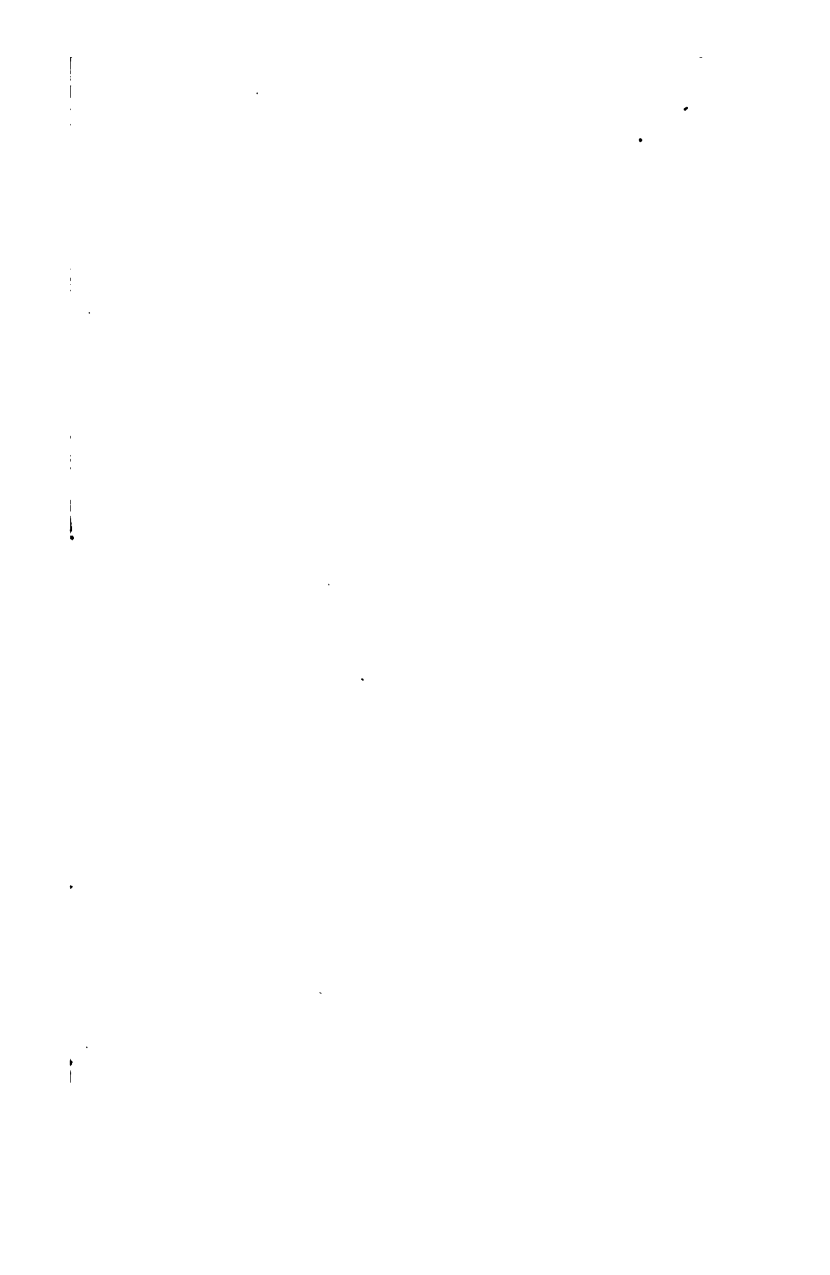
absorption of carbonic acid gas, and frees the lime from its hold on the silica.

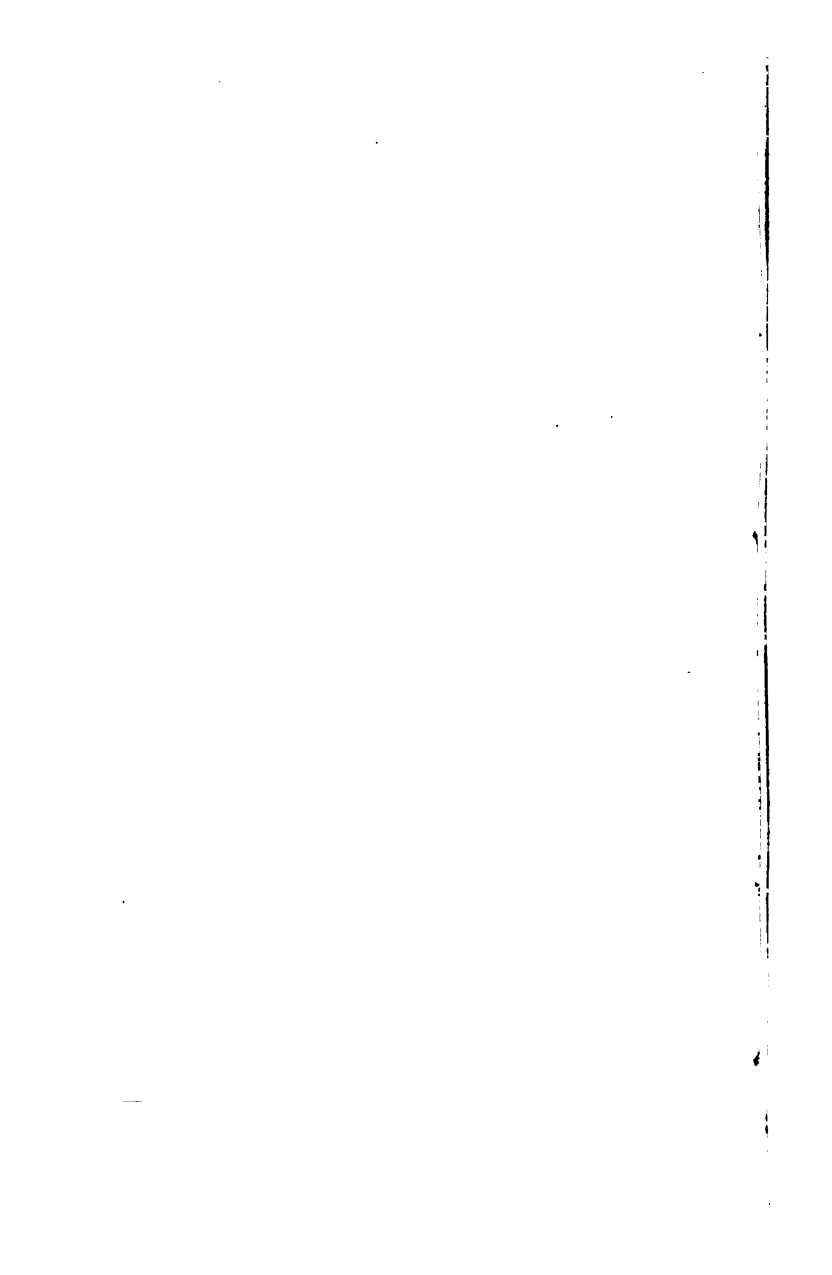
All porous brick, and a great number of the sandstones, when used in dry weather, should be well soaked in water in order to avoid the rapid absorption of moisture from the mortar, and thereby preventing the formation of carbonate, as we have already shown. Take, for example, Tullamore or other equally porous bricks set in the best possible mortar, and you can at any time easily pick them out of the wall without a particle of the mortar adhering; and, in addition, you will find the latter can be without difficulty reduced to powder. Let the same bricks be steeped in water, and used in a position where the mortar must dry slowly—as in an underground arch—and all the efforts of labour, after a sufficient time has elapsed, will not remove a single brick whole, as they will be smashed to pieces before you can disturb their hold of the mortar.

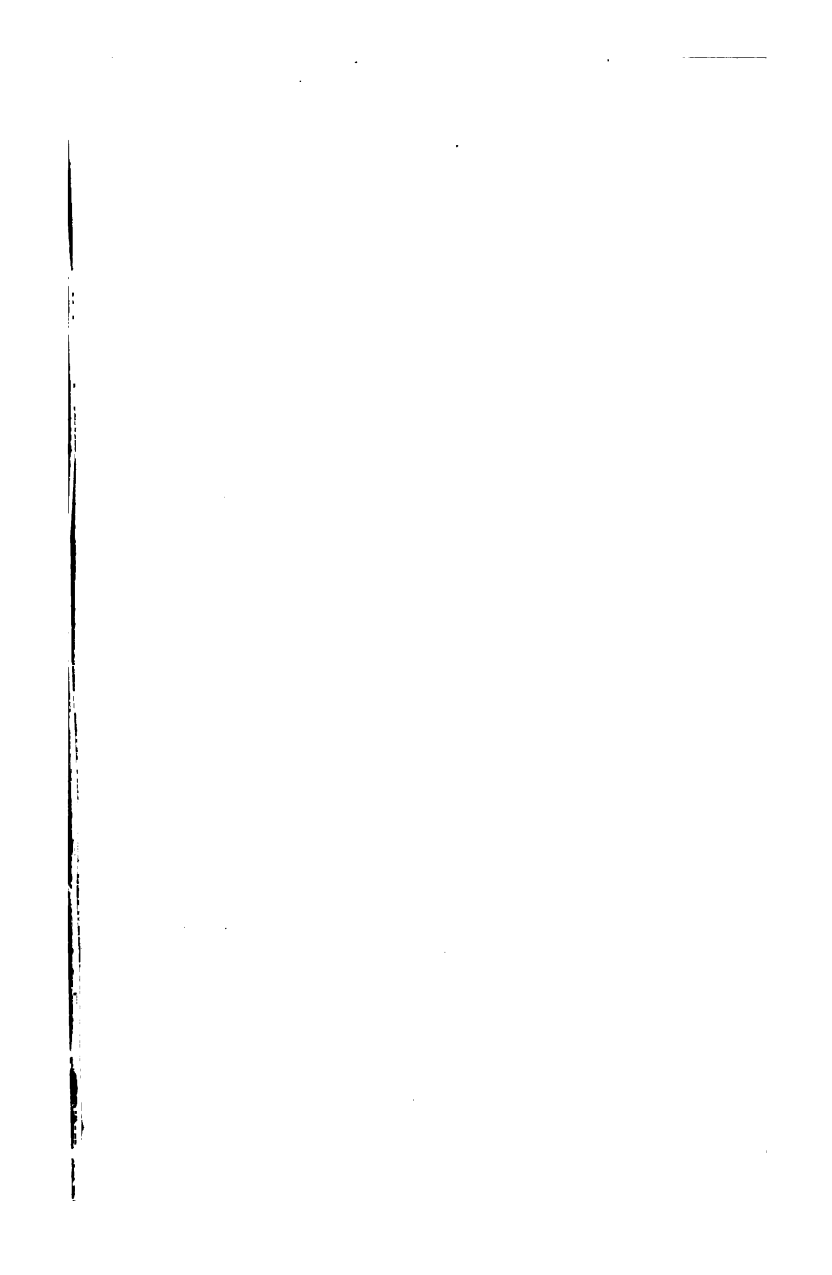
Much has been said, and much has been written about the tenacity of the mortar of the ancients; the most impossible ingredients have been stated as being used in its composition; but the great secret existed in using only proper materials, and attending to ordinary natural laws. This, we fear, we can never teach where a merciless economy or a slap-dash style of building prevails.



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